An Introduction to Parallel Supercomputing

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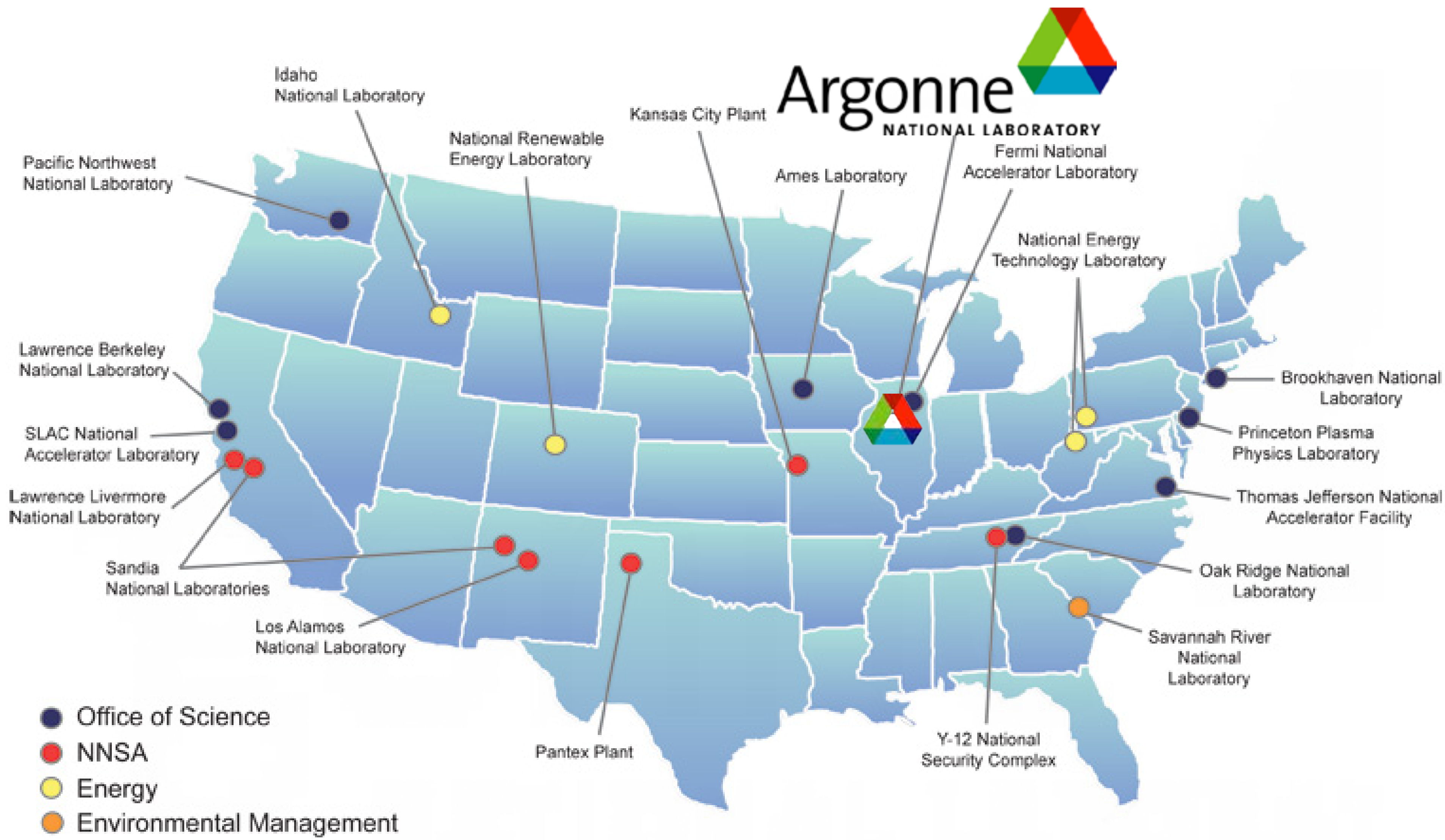
Argonne & the DOE National Laboratory System




Argonne National Laboratory
$675M /yr budget
3,200 employees
1,450 scientists/eng
750 Ph.D.s

Direct descendent of Enrico Fermi's Metallurgical Laboratory

- Opened in Feb 1943 (as new site for Chicago's Metallurgical Laboratory)
- Became Argonne National Laboratory in July 1946 (first national laboratory)

MCS Division meeting c. 1983

- "If our R&D is going to be relevant ten years from now, we need to shift our attention to parallel computer architectures"
- "Los Alamos has a Denelcor HEP: let's experiment with it"


MIRA

POOMA Project: 1996
John Reynders

Parallel Platform Paradox

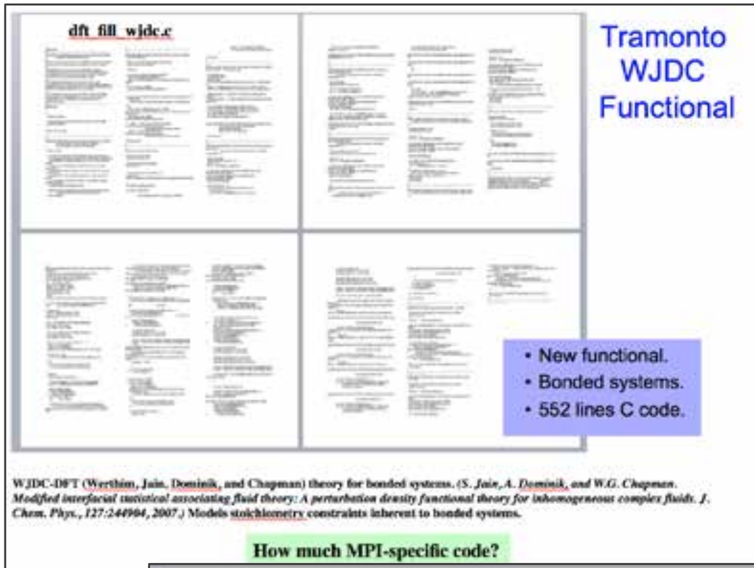
"The average time required to implement a moderate-sized application on a parallel computer architecture is equivalent to the half-life of the latest parallel supercomputer."

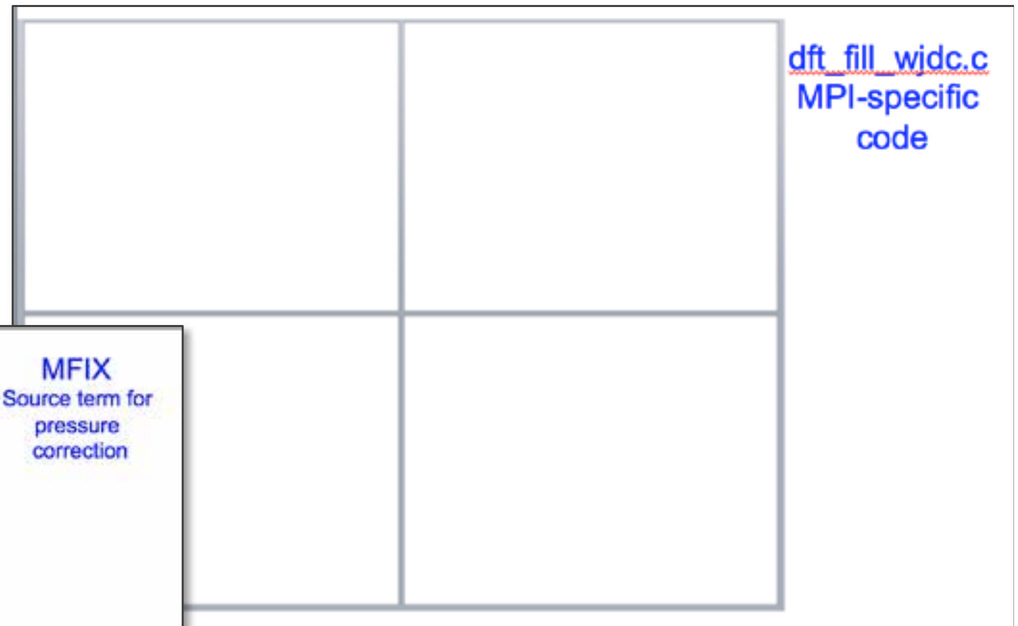
"Although a strict definition of "half-life" could be argued, no computational physicist in the fusion community would dispute the face that most of the time spent implementing parallel simulations was focused on code maintenance, rather than on exploring new physics. Architectures, software environments, and parallel languages came and went, leaving the investment in the new physics code buried with the demise of the latest supercomputer. There had to be a way to preserve that investment."

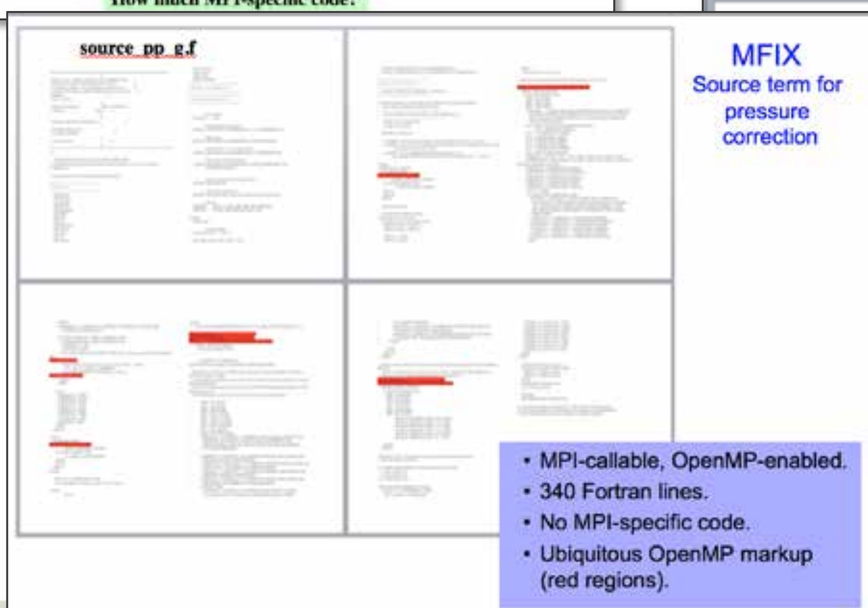
Pete’s Investment Recommendations

- **Other People’s Libraries**
- **Encapsulation**
  - Parallelism & Messaging & I/O
- **Embedded Capabilities**
  - Debugging
  - Performance Monitoring
  - Correctness Detection
  - Resilience
- **The Two Workflow Views**
  - Science: (problem setup, analysis, etc.)
  - Programmer: (mod, testing, document, commit)
- **Automation**
  - A+ Build system, nightly test and build, configuration
  - Embedded versioning and metadata
- **Community: web, tutorial, email, bug tracking, etc**

Encapsulation Examples from Mike Heroux…

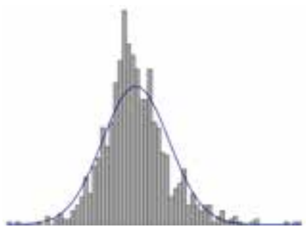




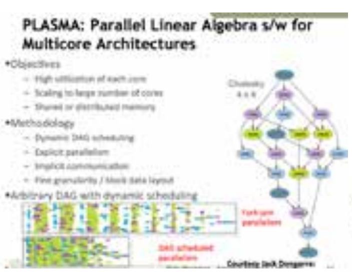


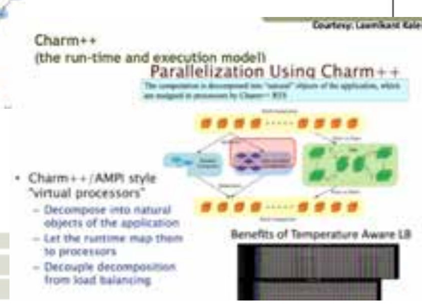
Threads/Tasks: Managing Exploding Parallelism

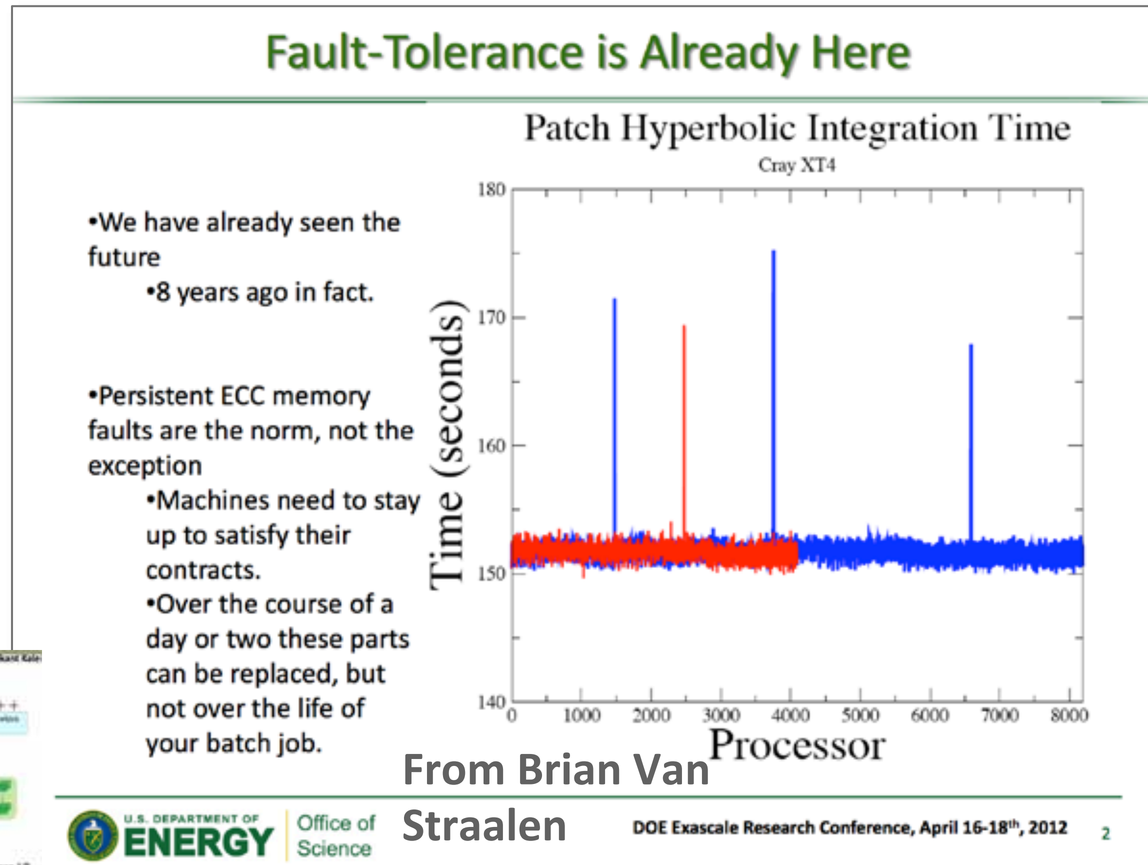
- **Dynamic parallelism and decomposition**
  - Programmer cannot hand-pick granularity / resource mapping
    - (equal work != equal time)



Variability is the new norm:
Power
Resilience
Intranode Contention







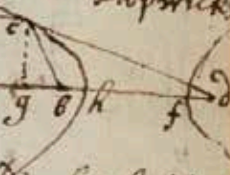
From Brian Van Straalen

Future Trends: Invest Wisely

Trending Up	Trending Down
Asynchrony, Latency Hiding	Block synchronous
Over Decomp & Load Balancing	Static partitioning per core
Massive Parallelism	Countable parallelism
Reduced RAM per Flop	Whole-socket shared memory
Software-managed memory	Simple NUMA
Expensive Data Movement	Expensive flops
Fault / Resilience Strategies	Pure checkpoint/restart
Low BW to Storage, in-situ analysis	Save all, let the viz guys sort it out

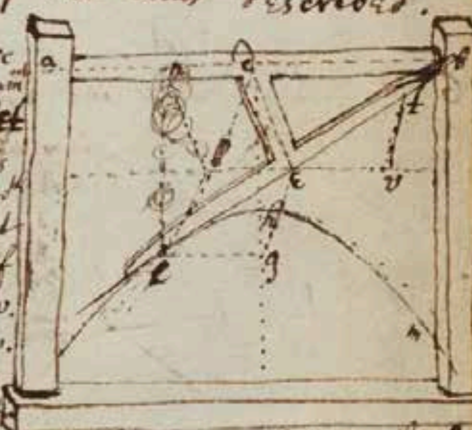
Of Refractions.

1 If ye ray ac bee refracted at the center of ye circle acdg towards d & ab⊥be⊥gc∥ed. Then suppose ab : ed :: d : e. See Cartes Dioptricks



2 If there be an hyperbola the distance of whose foci bd ~~which~~ are to its transverse axis hf as d to e. Then ye ray ac∥bd is refracted to ye exterior focus (d). See C: Diopt.

3 Having ye proportion of d to e, or bd : hf. The Hyperbola may bee thus described.



1 Upon ye centers a, b let ye instrument adbtec bee moved in wch instrument observe yt ad⊥de⊥cet & yt the beame cet is not in ye same plane wth adbe but intersects it at ye angle tev soe yt if tv⊥ev, then d : e :: et : tv. Or d : e :: Rad : sine of ∠tev. Also make de = $\frac{q}{2}$, i.e. halfe ye transverse diameter. Then place the fiduciall side of ye plate ckm in the same plaine wth ab. & moving ye instrument adbec to & fro its edge cet shall cut or weare it into ye shape of ye desired Parabola. Or the plate ckm may bee filed away untill ye edg cet exactly touch it every where.

2 By the same proceeding Des-Cartes concave Hyperbolicall wheels may bee described by being turned wth a chissell &c whose edge is a streight line inclined to the ~~axis~~ axis of the mandrill by ye ∠tev wch angle is found by making d : e :: et : tv :: Rad : sine of ∠tev.

3 By the same reason a wheele may be turned Hyperbolically concave ye Hyperbola being convex. Or a Plate may bee turned Hyperbolically concave